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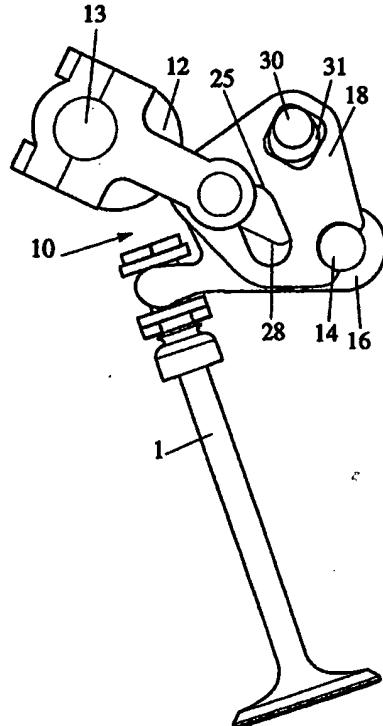
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(54) Title: ADJUSTMENT MECHANISM FOR VALVES

(57) Abstract

An apparatus for adjusting the motion characteristics of a valve of an engine, comprising an adjustment means to vary the valve opening and closing angle, or the valve lift including a guide element movable from a first position to a second position, and having a path adapted to receive a guide member of a valve actuation means, the guide member received in the guide path having a trajectory, when the adjustment means is in the first position, different of the trajectory of the guide member when the adjustment means is in the second position.



ADJUSTMENT MECHANISM FOR VALVES

FIELD

The present invention relates to improvements in engines, such as internal combustion engines, particularly to the actuation of valves and most 5 particularly, poppet valves for internal combustion engines.

The present invention also has application to engines or pumps which uses valves.

BACKGROUND

The available torque from an internal combustion engine is largely 10 dependant on the volumetric efficiency of the engine. For reciprocating piston engines, this efficiency is a measure of the volume of atmospheric air drawn into the cylinder/s during an induction stroke, relative to the swept volume of the cylinder/s.

The valve timing of the reciprocating internal combustion engine has a 15 significant effect on the volumetric efficiency of the engine at particular engines speeds. An engine having fixed valve timing, ie a fixed crankshaft angle for valve opening before piston at top dead centre and a fixed crankshaft angle for valve closing beyond top dead centre, will have a particular engine speed where it operates most efficiently. At this speed, the fixed synchronisation of the 20 inlet and exhaust valves opening and closing relative to the piston position create the combination giving the most torque.

Obviously it is desirable to have the most torque possible available over a wide range of engine speeds. To achieve the maximum torque at high engine speeds, it is desirable to have the valves (inlet and exhaust) open for as much 25 piston travel as possible. This gives air more time to enter and exhaust gases more time to exit the cylinder and therefore increases volumetric efficiency. However, there are limiting factors for how much piston travel, or how much of an angle (of crankshaft rotation) the inlet and exhaust valves can be kept open. For example, increasing the angle that the valves are open increases the angle 30 that both the inlet and exhaust valves are open at the same time, which is called valve overlap. Valve overlap is desirable at high engine speeds as it increases torque output. However, the same amount of valve overlap that produces good

torque at high engine speeds will cause the engine to run poorly and reduces torque output at low engine speeds. Accordingly, in general, opening the valves earlier and closing them later improves volumetric efficiency at high engine speed at the expense of torque at low engine speed. Conversely decreasing 5 valve overlap increases engine torque at low engine speeds but does not give the best efficiency at high engine speeds.

It is therefore desirable to have a mechanism whereby the timing of the valve opening and closing can be adjusted according to parameters such as engine speed, in order to optimise the torque across a range of engine speeds.

10 Further, other parameters, such as for example, throttle position and which gear is engaged, may be used to vary the timing of the opening and closing of the valves.

Apart from valve timing, there are other factors which are important in the operation of reciprocating engine poppet valves. Firstly, just before the valve is 15 opened, the valve actuator should accelerate slowly towards the valve, in order to reduce then eliminate the clearance between the valve and the actuator or between any intervening tappet arrangement and the actuator. This is to ensure that the valve and actuator do not impact on each other with large velocities or forces. The valve then needs to be opened as quickly as possible in order to 20 facilitate the filling of the cylinder with fresh air and fuel in the case of an intake valve, or empty the cylinder of exhaust gas in the case of an exhaust valve. Once opened, the valve should be held open for as long as possible before closing rapidly. The valve should then reseat as gently as possible and then stay closed until the cycle repeats. As there should be no radical changes in 25 motion, (excessive acceleration) of the valve, a substantially sinusoidal motion has been found to be acceptable in providing a path for valve movement.

The actuation of valves and the control of their motion has been accomplished in the past by the use of camshafts. Camshafts have an eccentric cam lobe that actuates a valve, wherein the profile of the cam lobe determines 30 the motion characteristic of the valve. A problem with this arrangement is that the camshafts spin rapidly and the valves rely on valve springs to keep them in contact with the outer surface of the cam lobe. As the camshafts spin more

rapidly, the valves can leave the surface of the cam lobe due to inertia. This problem has been addressed in part by increasing the strength of the valve spring, however this makes opening the valve harder and increases wear on the cam lobe surface.

5 Another major problem with camshafts is the inability to change the lobe shape, making modification of the motion characteristics of the valve difficult. To modify the valve timing, the camshaft needs to be replaced or machined, with the result that torque is only optimised over a narrow speed range for a particular cam lobe profile. This is one of the reasons that engines that perform
10 well at high speed usually lack torque in the lower range of engine speeds. Further, as the valve springs push against the cam lobes as the camshaft rotates, significant twisting forces are generated along the camshaft, which can result in camshaft breakage.

There are existing devices that attempt to solve some of the above
15 problems, however, none are completely satisfactory. One device is a cam shaft having two standard cam lobes for the two inlet valves, and a third cam lobe between the two standard inlet lobes. When the engine is spinning below a certain engine speed, the inlet valves are actuated by the standard cam lobes. When the engine accelerates over a predetermined engine speed, a pin
20 engages with the valve's actuators, which allows both the valves to be actuated by the third cam lobe, which has a different profile suited to high engine speeds, wherein the inlet valves open earlier and stay open longer. A similar mechanism operates in the exhaust valve camshaft. This system has the disadvantage that it is not possible to vary the valve opening and closing times
25 between the two predetermined valve motion characteristics, ie there are only two valve opening durations available. This results in a marked "step" in torque output from lower rpm to higher rpm and fails to achieve the maximum torque output across the whole range of engine speeds, as effectively only two specific engine speeds are optimised.

30 Another method of varying the valve opening and closing angle is where the camshaft speed is not always half the crankshaft speed over parts of a single revolution, but varies according to the engine speed. For example, at low rpm

the camshaft may spin at the standard rate of half the crankshaft speed. At higher engine speeds, a mechanism mounted on the camshaft causes the camshaft to spin at lower than half crank speed while opening the valves and keeping them open, thus ensuring that the valves are open over a wider angle than at lower speed. In order to make up lost time (as the crankshaft must average one revolution for every two crankshaft revolutions), the camshaft must then spin faster than half crank speed for the remainder of the revolution to ensure that it is in the correct position when it is time for the valves to open again. This system is obviously less than ideal as a complex mechanism is used to vary the speed of the camshaft with respect to the crankshaft over a single revolution. Further, valve lift cannot be modified as the cam lobe profiles cannot be modified.

Another disadvantage of most valve actuation means is that they comprise a cam shaft which opens the valves. Camshafts are difficult to manufacture, and are subject to wear and breakage.

It has also been found that the method of adjusting valve clearances between the top of the valve and the valve actuator, for example rocker arm or cam shaft lobe, has disadvantages, such as the need for the clearance adjusting mechanism to be on the rocker arm, thereby adding inertia to the rocker arm, or the use of shims which are difficult to get at under the cam lobes, and require buckets to locate them, which add to the overall length of the valve assembly and therefore add to the dimensions of the engine.

SUMMARY OF INVENTION

It is an object of the present invention to alleviate at least one disadvantage associated with the prior art.

To this end, the present invention provides a means for adjusting the motion characteristics of a valve. The motion characteristics of the valve include timing, such as the crankshaft's angular location before the top dead centre reference angle where the valve opens, duration, such as the angle of crankshaft rotation for which the valve will stay open, lift or travel the amount of lift of the valve for a given crankshaft angular location, rate of travel and/or force. In one form, the adjustment is actuated mechanically. In another form, the

adjustment means is located between a valve actuation means and the valve. Advantageously, adjusting the motion characteristics of the valve by way of the present invention, enables selection of engine performance criteria from a range of predetermined characteristics, together with a selection of the degree to 5 which the criteria is to be performed. For example, the adjustment of valve motion characteristics may be selected in a manner which accentuates engine torque. Or, selection may be made to accentuate engine fuel economy.

It may also be desirable to produce a valve actuation means which produces an approximate sinusoidal motion of valve lift in relation to crankshaft 10 rotation and/or which also allows the motion characteristics of the valve to be varied.

Usually the valve actuation means includes a rotating member.

Typically the adjustment means varies the valve opening angle, and/or the valve closing angle and/or the valve lift, either individually or collectively. It 15 has been found that it is advantageous to vary the valve lift and duration, and that while these may be done separately, it has been found that it is beneficial to increase valve lift and valve spring duration as engine speed rises.

Accordingly, it is desirable that the adjustment means varies the valve opening and closing angle and the valve lift collectively.

20 In another form, the invention provides an apparatus for adjusting the motion characteristics of a valve, including adjustment means to adjust the valve motion in accordance with the adjustment means travel along a non-straight path.

In another form, the invention provides an adjustment means for use in an 25 apparatus for adjusting a motion characteristics of a valve comprising a plate having a guide path.

In another form, the invention provides an apparatus for adjusting the motion characteristics of a valve including a first guide path and a second guide path wherein the motion characteristics of the valve are determined by 30 differences in shape and/or alignment between the first and second guide paths.

In another form, the invention provides an apparatus for adjusting the clearance of a valve actuated by a desmodromic valve actuation means

including a valve having a threaded end portion.

In a preferred embodiment, the means for adjusting the motion characteristics of the valve include an adjustment member having a guide path and a pivotally mounted valve actuation member having at least one guide surface, wherein a pin moves along both the guide path and the guide surface, causing the pivotally mounted actuation member to pivot and move the valve.

Typically, the pin is driven in a substantially cyclic motion.

Desirably the guide path of the adjustment member and the guide surface of the valve actuation member are not collinear over their entire length, ie there is a difference in the paths such that they deviate from each other at least over part of their length. This difference in paths produces the movement of the actuation member as the pin travels along both paths. also, a kinematic inversion of pin and guide is contemplated as an alternative embodiment.

PREFERRED EMBODIMENT

One or more of the preferred embodiments of the present invention will now be described, with reference to the accompanying drawings, wherein:

Figures 1a-1d show a schematic representation of an adjustment mechanism in accordance with the present invention in various states of assembly;

Figure 2a shows a schematic side view of the adjustment mechanism of the present invention and a prior art valve actuation mechanism;

Figure 2b shows a schematic view of a non-desmodromic adjustment mechanism of the present invention and a prior art valve actuation mechanism.

Figure 3 shows an isometric view of part of a first embodiment of the adjustment mechanism of the present invention;

Figure 4 shows an isometric view of all of the first embodiment of the adjustment mechanism of the present invention;

Figures 5a and 5b show end views of a second embodiment of the adjustment mechanism of the present invention;

Figures 6a and 6b show end views of the adjustment mechanism shown in figures 5a and 5b;

Figure 7 is a graph of typical extremes of variation in lift and duration of

the valves compared with the position of the crankshaft, as varied by the adjustment mechanism of the present invention;

Figure 8 is a first embodiment of a guide plate of the adjustment mechanism of the present invention;

5 Figure 9 is a second embodiment of the guide plate of the adjustment mechanism of the present invention;

Figures 10a-10d are embodiments of rocker arms of adjustment mechanism of the present invention;

10 Figure 11 is a schematic side view of a first embodiment of a slot of a guide plate of the adjustment mechanism in accordance with the present invention;

Figure 12 is a schematic side view of a profiled surface of a guide plate of the adjustment mechanism in accordance with the present invention;

15 Figure 13 is a schematic side view of a second embodiment of the slot of the guide plate of the adjustment mechanism of the present invention;

Figure 14 is a schematic representation of the slot of the guide plate of the adjustment mechanism of the present invention;

Figures 15a-15d are embodiments of a sliding pin of the adjustment mechanism of the present invention;

20 Figures 16a-16d are embodiments of the guide plates of the adjustment mechanism of the present invention;

Figure 17a is a first embodiment of a guide plate adjustment means of the adjustment mechanism of the present invention;

25 Figure 17b is a second embodiment of the guide plate adjustment means of the adjustment mechanism of the present invention;

Figure 18a is a perspective view of a valve clearance adjustment mechanism in accordance with the present invention.

Figure 18b is an exploded perspective view of the valve clearance adjustment mechanism shown in figure 18a.

30 Referring to Figures 2a, 2b, 4, 5a and 5b, a mechanism 10 is shown for adjusting the motion characteristics of a poppet valve 1. The mechanism 10 includes a valve actuation means, for example a valve crankshaft 12 having a

a guide path 25 of the guide plate 18. As the valve crankshaft 12 rotates, the pin 26 is constrained to move along the path 25 of the guide plate 18, however the guide plate 18 can move from a first position 20 to a second position 22, and any number of positions therebetween. The profile of the guide path 25, as 5 shown in the figures, defines the trajectory of pin 26. The pin 26 also slides along path 28 of the rocker arm 16, and the different profile between the path 28 and path 25 causes the rocker arm 16 to pivot back and forth about pivot point 14. The actuator 32 attached to rocker arm 16 moves with the arm 16 and contacts the end of valve 1, pushing the valve open and pulling the valve 10 closed. Where non-desmodromic valve actuation is desired, a valve spring may close the valve 1.

The position of the guide plate 18 can be varied, in the case of Figures 2a, 2b, 3 and 4 by rotation of the rocker shaft 14, in a second embodiment adjustment 1s due to eccentric adjusting shaft 30 as can be seen in figures 5a, 15 5b, 6a, 6b 17a and 17b. The shaft 30 has an eccentric off-centre lobe 31 which can be turned within aperture 34, thus causing the guide plate 18 to move from a first position 20 wherein the motion characteristics as shown by line 40a and 40b of figure 7 suit low engine speed, to a second position 22, wherein the motion characteristics of the valve suit high engine speeds shown by line 42a 20 and 42b, also of in figure 7. The movement of the guide plate 18 can be seen in the comparison of open valve positions shown in figures 5a and 5b. In figure 5a, the adjusting shaft 30 and lobe 31 position the guide plate 18 in the first position 20. In figure 5b, the adjusting shaft 30 and lobe 31 position the guide plate 18 in the second position 22 and thus the maximum valve opening, as 25 seen in figure 5b is greater than the maximum valve position seen in figure 5a. The operation of the shaft 30 and lobe 31 in the aperture 34 in the guide plate is shown in figures 17a and 17b and will be described in more detail below.

The motion characteristics of the valves can be seen in figure 7, wherein line 40a represents the valve lift of an inlet valve (vertical axis) versus crankshaft 30 rotation angle (horizontal axis) for the valve 1 actuated by valve crankshaft 12 while the guide plate 18 is in the first position 20. The exhaust valve motion characteristics when the guide plate 18 is in the first position 20 are shown by

guide plate 618 can be controlled by the rotation of the shaft 30.

A control means (not shown) is used to control the rotation of the shaft 30 for each mechanism 10 which enables the guide plate to be positioned anywhere between the first position 20 and the second position 22. The control 5 means may be a simple device for advancing the valve opening by twisting the shaft, or any other suitable means for moving the guide plate. Such mechanisms are commonly used to advance the ignition timing as engine speed rises. The valve timing in this case may be adjusted either with or independent of the ignition timing.

10 A further embodiment of a guide plate 518 is shown in figure 9 wherein the guide plate 518 is mounted to a rotatable pivot point 535, so that adjustment of the motion characteristics of the valve can be made by rotating pivot point 535 to which the guide plate 518 is attached, to any position between the two positions as shown by the arrow and dotted line, rather than linear motion as 15 shown by the arrow in figure 8.

It should also be understood that the guide plates in any of the embodiments disclosed may be positioned in discrete locations between the first position 20 and the second position 22, for example by the use of a stepper motor. This would allow the position of the guide plates to be varied in steps 20 according to data from various parameters such as engine speed, rate of change of engine speed, throttle position and gear position. Accordingly, a fuzzy logic table could be set up to position the guide plates in the optimum position for a set of predefined parameters.

Figures 16a to 16d show further alternative arrangements for the guide 25 plates. Each guide plate is arranged to be mounted in such a way that its position is able to be controlled in order for the position of the path for the sliding pin to be controlled. In a non-desmodromic arrangement as shown in figure 16b and 16d, there is no requirement for the path to be a slot, and as such profiles 125 and 325 can be used, as a spring acting on the valve can be used in a 30 conventional manner to close the valve and accordingly there will always be pressure on either profile 125 or profile 325 and the underside of the respective rocker arms 118 or 328. This arrangement has the advantage that there is a

large body of knowledge regarding the use of valve springs to close a valve. Also, the reciprocating rocker arms may be made lighter.

Embodiments of the means for adjusting the position of the guide plate is shown in figure 17a and 17b. Figure 17a relates to a method of 5 producing linear adjustment in the guide plate using a shaft 30 in an aperture 34 in the guide plate 18. The shaft has a lobe 31 which moves the guide plate to the desired position when the shaft 30 is turned. Aperture 34 is designed to move the guide plate 18 linearly, and therefore has substantially straight side walls. As many engines of the type that use poppet valves have numerous 10 valves in alignment, a single shaft with multiple lobes 31 can be used to move all the guide plates 18 simultaneously.

A further embodiment is shown in figure 17b, wherein the shaft 30 is used to cause a rotational motion in the guide plate 18. The twisting of the shaft 30 with eccentric lobe 31 in aperture 134 causes the guide plate to pivot about 15 fixed point 135. If the guide plate is mounted about a pivot point, as shown in figure 9, then the rotation of the shaft 30 will cause the guide plate to rotate, and thus increase or decrease the difference between the paths in the guide plate and rocker arm, which will effect the motion characteristics of the valve. As the aperture 134 is designed to move the guide plate 18 pivotally, side wall 136 is 20 longer than side wall 137.

In the above embodiments, the rocker arm has pivoted while the guide plate has moved either linearly or pivotally. It can be readily determined that the rocker arm could also move linearly in response to the movement of the pin in the path of the guide plate. Further, the guide plate may be fixed in place, and 25 all the adjustment movements can take place on the rocker arm, eg the rocker arm could have its pivot point moveable with respect to the guide plate. This arrangement has the advantage that the guide plate is then fixed, and all the movement is undertaken by the rocker arm, making the mounting of the guide plate greatly simplified.

It can be seen from the embodiments disclosed that the movement of the guide plate 18 from its first position to the second position causes the sliding pin 26 travelling along path 25 to not only increase the crank rotation angle across

which the valves open, but also increases valve lift at the same time. These aspects in combination produce a result that is very desirable, as two of the valve characteristics change with only a change in one parameter, that being the movement of the guide plate. It is desirable to have the valves increase their lift at high engine speeds to ensure that the maximum amount of air enters the cylinder or exhaust gas exits from the cylinder in the time provided. However, at low engine speeds, it has been found that increased turbulence in the air entering the cylinder is desirable as it assists in the atomisation of the fuel in the air. When engines operate at low speeds, the velocity of the air entering the cylinder is also low, and therefore there is not as much turbulence in the air as it passes the inlet valves into the cylinder. It has been found that decreasing the valve lift and duration increases turbulence and therefore increases fuel atomisation, which increases torque. At higher engine speeds, the turbulence from the faster air flow provides sufficient energy for fuel atomisation, and the limiting factor becomes the amount of air able to be squeezed into the cylinder. The present invention allows for the adjustment of not only the valve opening duration, but also valve lift with only one parameter being adjusted.

The motion characteristics of the valve may also be varied in accordance with factors such as throttle position and also which gear is selected.

It should be noted that it is not essential to increase valve lift and duration with engine speed, and that it may be desirable under certain circumstances to decrease valve lift and/or durations of the inlet and/or exhaust valve as engine speed increases which the present invention is also able to accommodate.

In figure 18a there is shown a guide plate 418 used in desmodromic valve actuation, having two branches 420, each branch having an actuator 32. The actuators 32 sit between an upper flange member 422 and a lower flange member 424 at the upper end of a valve 1. The valve 1 includes a threaded portion 426, which has a lower nut 425 including the lower flange member 424, threadedly attached thereto, as shown in figure 18b. An upper nut 428, which is threadedly attached to the threaded portion 426 of the valve 1, includes the upper flange member 422. The gap between the upper flange member 422 and the lower flange member 424 may be set by an intermediate shim member (not

11. The apparatus of anyone of claims 3 to 10, wherein the valve opening and closing angle in relation to crankshaft position is variable between two predetermined angles.
12. The apparatus of claim 11, wherein at least 3 angles are selected over a range of engine speed.
13. An apparatus for adjusting the motion characteristics of a valve, including adjustment means to adjust the valve motion in accordance with the adjustment means travel along a non-straight path.
14. An apparatus as claimed in claim 13, wherein the adjustment means has a guide element and a guide member, wherein the guide member moves along a guide path in the guide element and along a guide path in a valve actuation means, causing the valve actuation means to move.
15. An apparatus as claimed in claim 13, including a rocker arm rotatably mounted around a point, a guide plate adjustable in relation to the point and an actuation means for moving a guide member along a guide path in the rocker arm and the guide plate wherein differences in the guide paths is reduced when the guide plate is in a first position, compared to the difference in the guide path when the guide plate is in a second position.
16. The apparatus of any preceding claim, wherein the motion characteristics of an inlet valve are variable independently of the motion characteristics of the exhaust valve.
17. An adjustment means for use in an apparatus for adjusting the motion characteristics of a valve comprising a plate having a guide path.
18. The apparatus of claim 17 including a valve actuator having a guide path difference from the guide path of the adjustment means.

19. The apparatus of claim 17, wherein the amount of non-alignment of the guide path of the adjustment means and the guide path of the valve actuator determines the motion characteristics of the valve actuator.
20. The apparatus of claim 18, wherein varying the position of the adjustment means changes the alignment between the guide path of the adjustment means and the guide path of the valve actuator thus adjusting the motion characteristics of the valve.
21. An apparatus for adjusting a motion characteristics of a valve including a first guide path and a second guide path wherein the motion characteristics of the valve are determined by differences in shape and/or alignment between the first and second guide paths.
22. The apparatus of any preceding claim, including a desmodromic valve actuation means.
23. An apparatus for adjusting the clearance of a valve actuated by a desmodromic valve actuation means including a valve having a threaded end portion.
24. The apparatus of claim 23, wherein the valve actuation means is located between a lower flanged member and upper flanged member, the upper flanged member being threadedly attached to the threaded valve portion.
25. The apparatus of claim 24, wherein the upper flanged portion and the lower flanged portion are spaced by a shim.
26. The apparatus of any preceding claim, wherein the valve actuation means includes a valve contact surface having a substantially constant radius.

AMENDED CLAIMS

[received by the International Bureau on 15 June 1998 (15.06.98);
original claims 1-26 replaced by new claims 1-23 (4 pages)]

1. An apparatus for adjusting the motion characteristics of a valve over a range of opening and closing angles including a member in communication with a valve actuator, wherein the member travels along a non-straight path in a guide, and the position of the guide is varied to adjust the direction of motion of the member.
2. The apparatus of claim 1 wherein the valve actuator is a pivotally located arm.
3. The apparatus of claims 1 or 2 wherein the guide includes a plate having a non-straight path.
4. The apparatus of any one of claims 1 to 3, wherein at least 3 different opening and closing angles are able to be selected over a range of engine speed.
5. An apparatus for adjusting the motion characteristics of a valve, including adjustment means to adjust the valve motion including an adjustment member and a guide member, the guide member moving along a guide path in the adjustment member and also along a guide path in a valve actuator, wherein the guide path in the adjustment member and the guide path in the valve actuator are not collinear, and the guide member moving along both paths causes the valve actuator to move relative to the adjustment member due to the differences in these paths.
6. An apparatus as claimed in claim 5, wherein the valve actuator includes a rocker arm rotatably mounted around a point, the adjustment member includes a guide plate adjustable in relation to that point, and an actuation means for moving a guide member along a guide path in the rocker arm and a guide path in the guide plate wherein differences in the respective guide paths are reduced

when the guide plate is in a first position, compared to the differences in the guide paths when the guide plate is in a second position.

7. An adjustment means for use in an apparatus for adjusting the motion characteristics of a valve comprising a plate having a guide path.

8. The apparatus of claim 7 including a valve actuator having a guide path different from the guide path of the adjustment means.

9. The apparatus of claim 8, wherein the amount of non-alignment of the guide path of the adjustment means and the guide path of the valve actuator determines the motion characteristics of the valve actuator.

10. The apparatus of claim 9, wherein varying the position of the adjustment means changes the alignment between the guide path of the adjustment means and the guide path of the valve actuator thus adjusting the motion characteristics of the valve.

11. An apparatus for adjusting the motion characteristics of a valve including a first guide path and a second guide path wherein the motion characteristics of the valve are determined by differences in shape and/or alignment between the first and second guide paths.

12. The apparatus of claim 11, wherein the first guide path is located in an adjustment member, which moves relative to the valve actuator to alter the differences between the shape and/or alignment of the first and second guide paths.

13. An apparatus for adjusting the motion characteristics of a valve including an adjustment means operatively situated between a valve actuation means and the valve, having an adjustment member with a guide path adapted to receive a guide member, the adjustment member being moveable between a

first position and a second position, wherein the guide member travelling along the guide path of the adjustment member has a different trajectory when the adjustment member is in the first position than when the adjustment member is in the second position.

14. The apparatus of claim 13 wherein the valve actuation means includes the means for determining the base timing of the valve actuation.

15. The apparatus of claim 13 or 14 where the guide member moves cyclicly.

16. The apparatus of any one of claims 13 to 15 where the position of the adjustment member can be varied over a given range of engine speeds.

17. The apparatus of any one of claims 13 to 16 where the position of the adjustment member can be varied over a given range of engine loads.

18. An apparatus for adjusting the motion characteristics of a valve including an adjustment member having a guide path, a guide element having a guide path and a valve actuating member, wherein the adjustment member moves relative to the guide element, thus modifying the motion of the guide member moving along the first and second guide paths which also modifies the motion of the guide element.

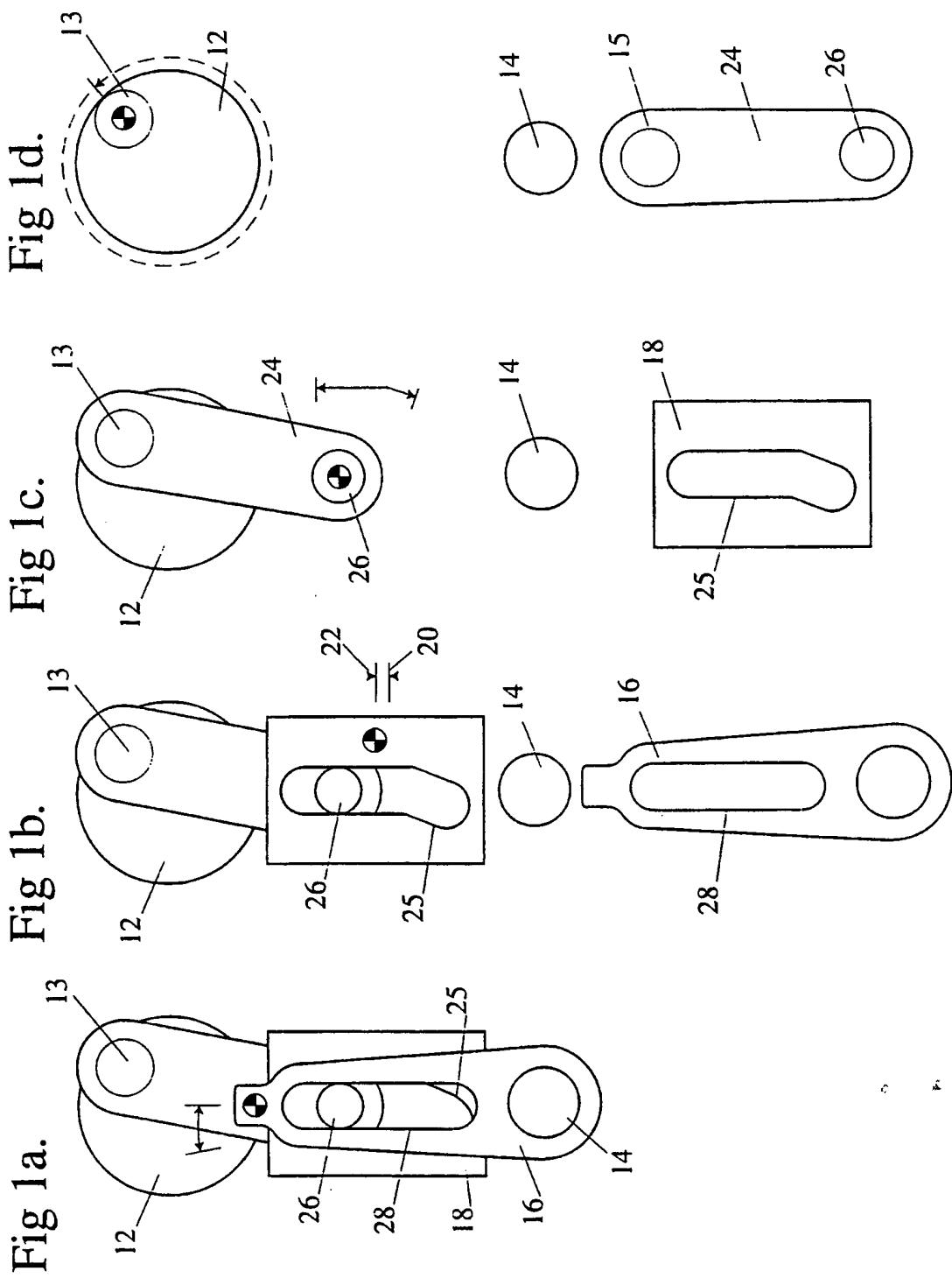
19. The apparatus of claim 18 wherein the adjustment member and guide element are plates.

20. The apparatus of any one of the preceding claims wherein the base timing of the adjustment mechanism is not varied.

21. The apparatus of any of claims 13 to 15 wherein the guide element is pivotally located.

22. The apparatus of any one of the preceding claims wherein the adjustment member is slidably located with respect to the pivot point of the guide element.

23. The apparatus of any one of the preceding claims, wherein the motion characteristics of an inlet valve are variable independently of the motion characteristics of the exhaust valve.



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Fig 2a.

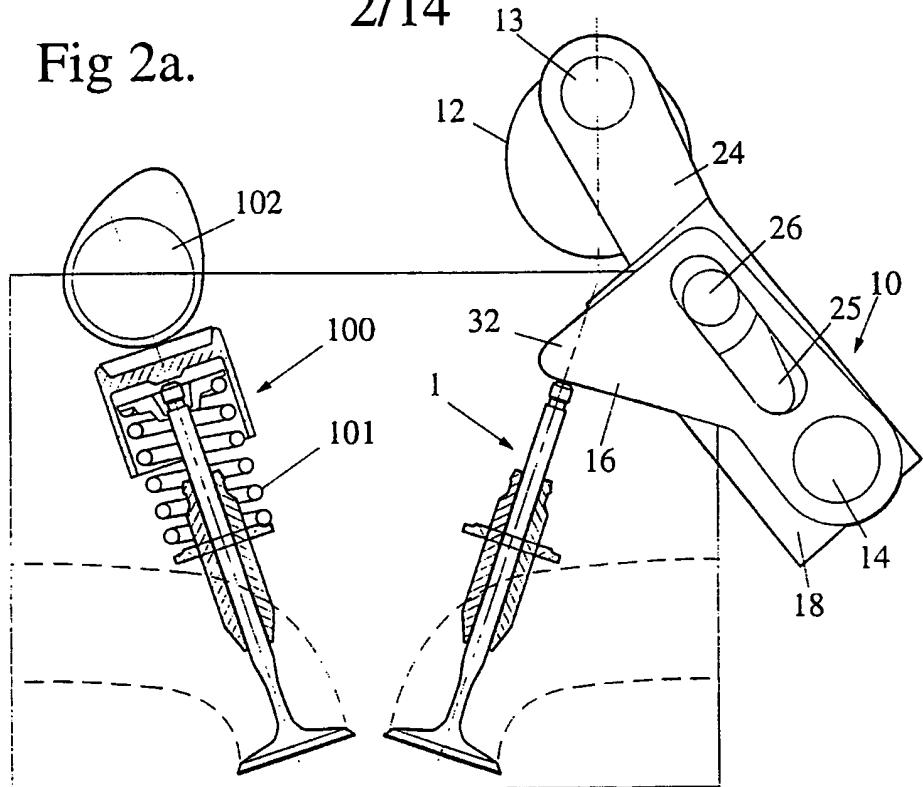
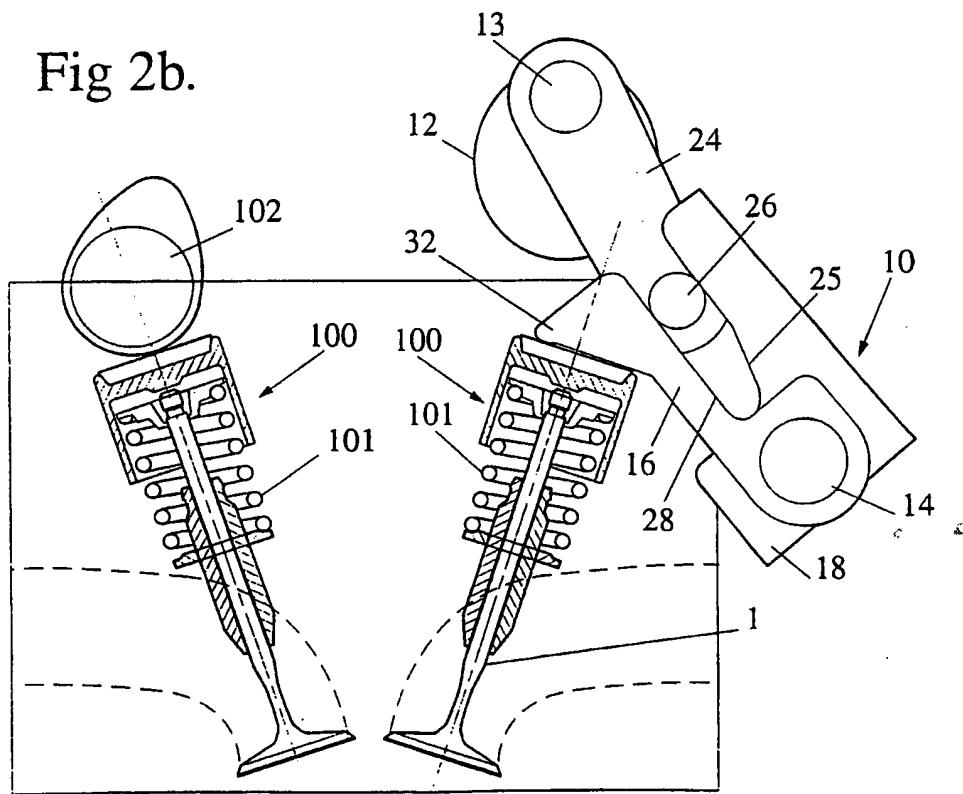


Fig 2b.



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Fig 3.

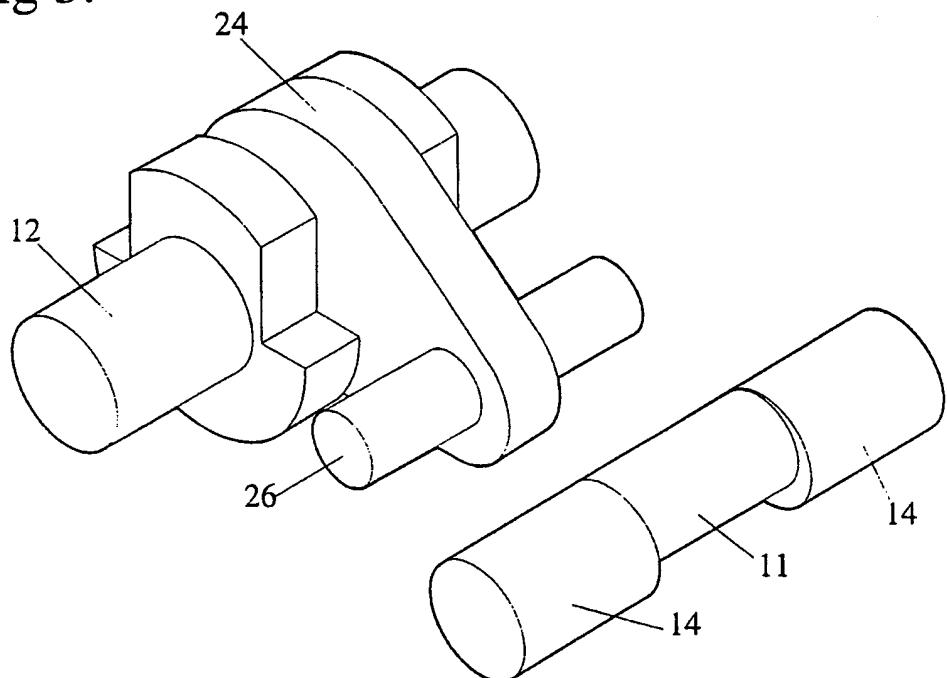
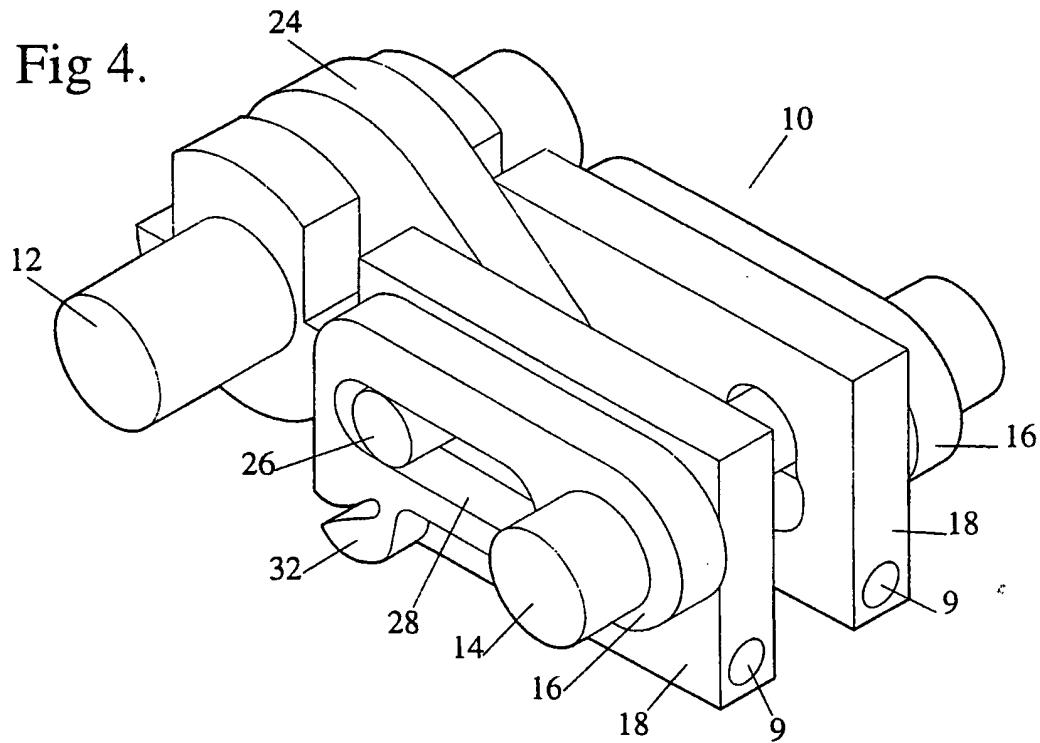


Fig 4.



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Fig5a.

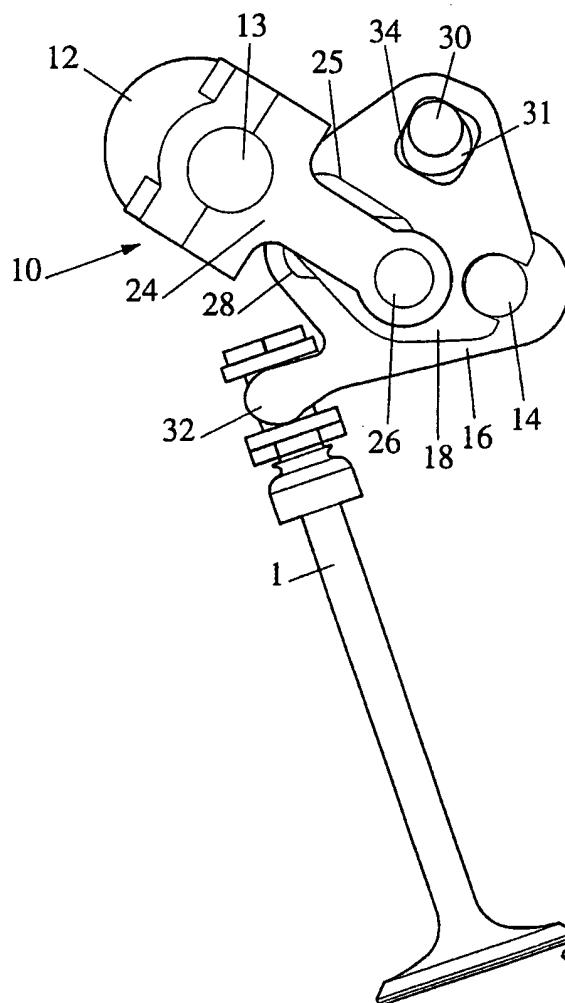
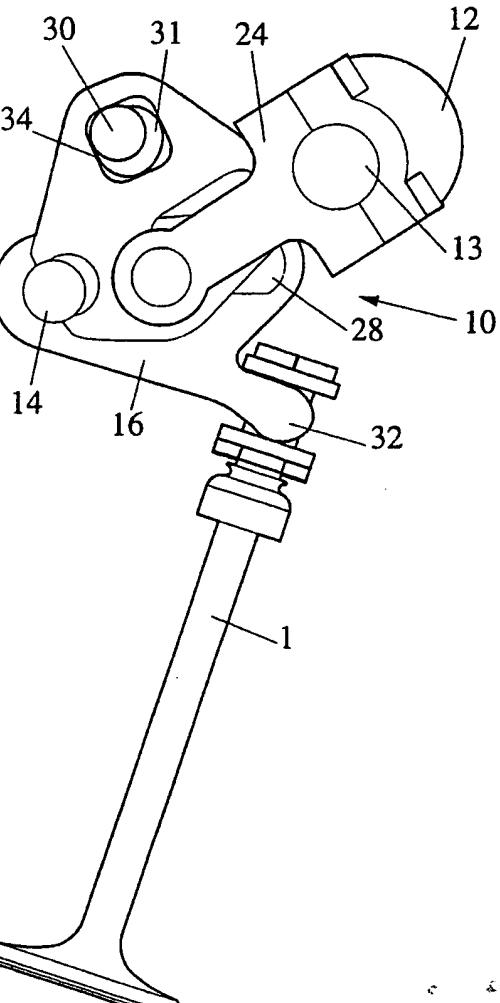


Fig5b.



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Fig6a.

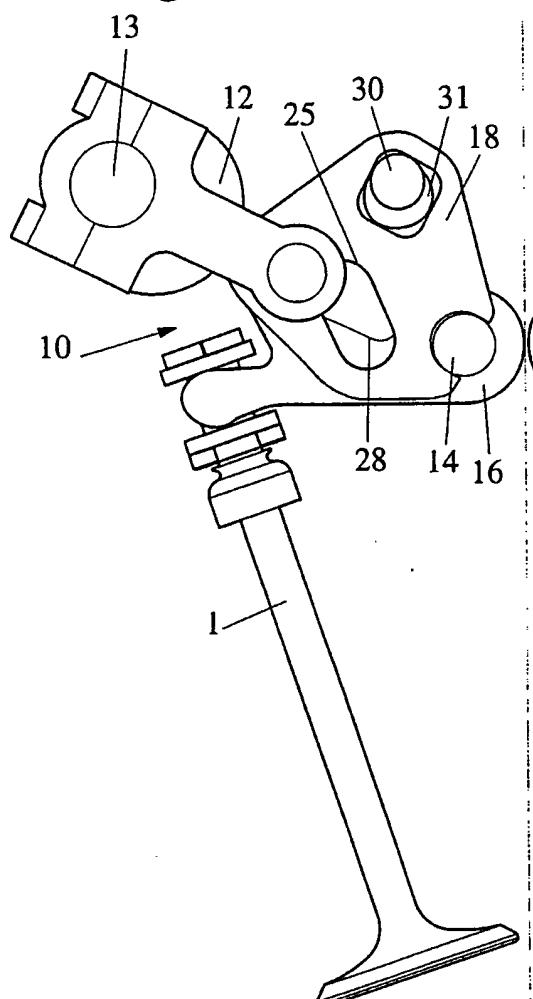
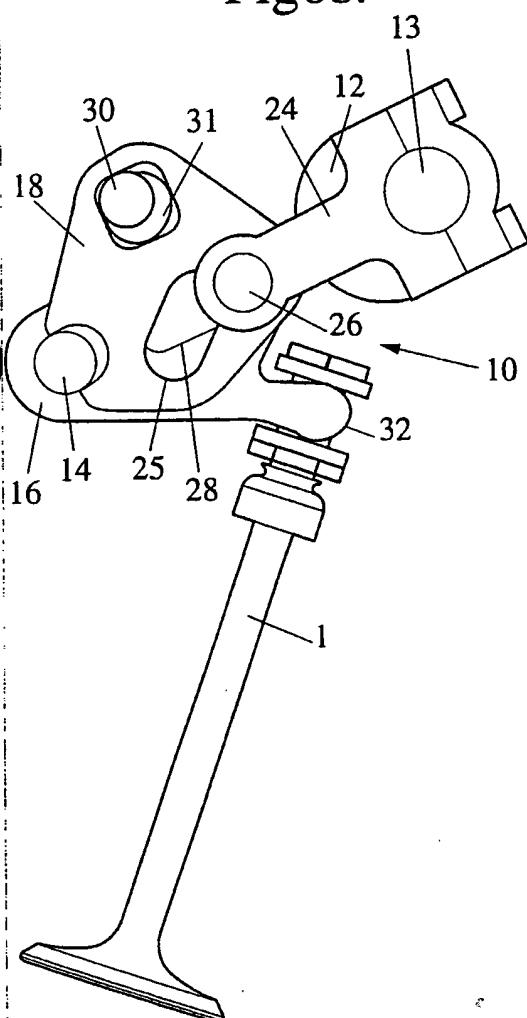
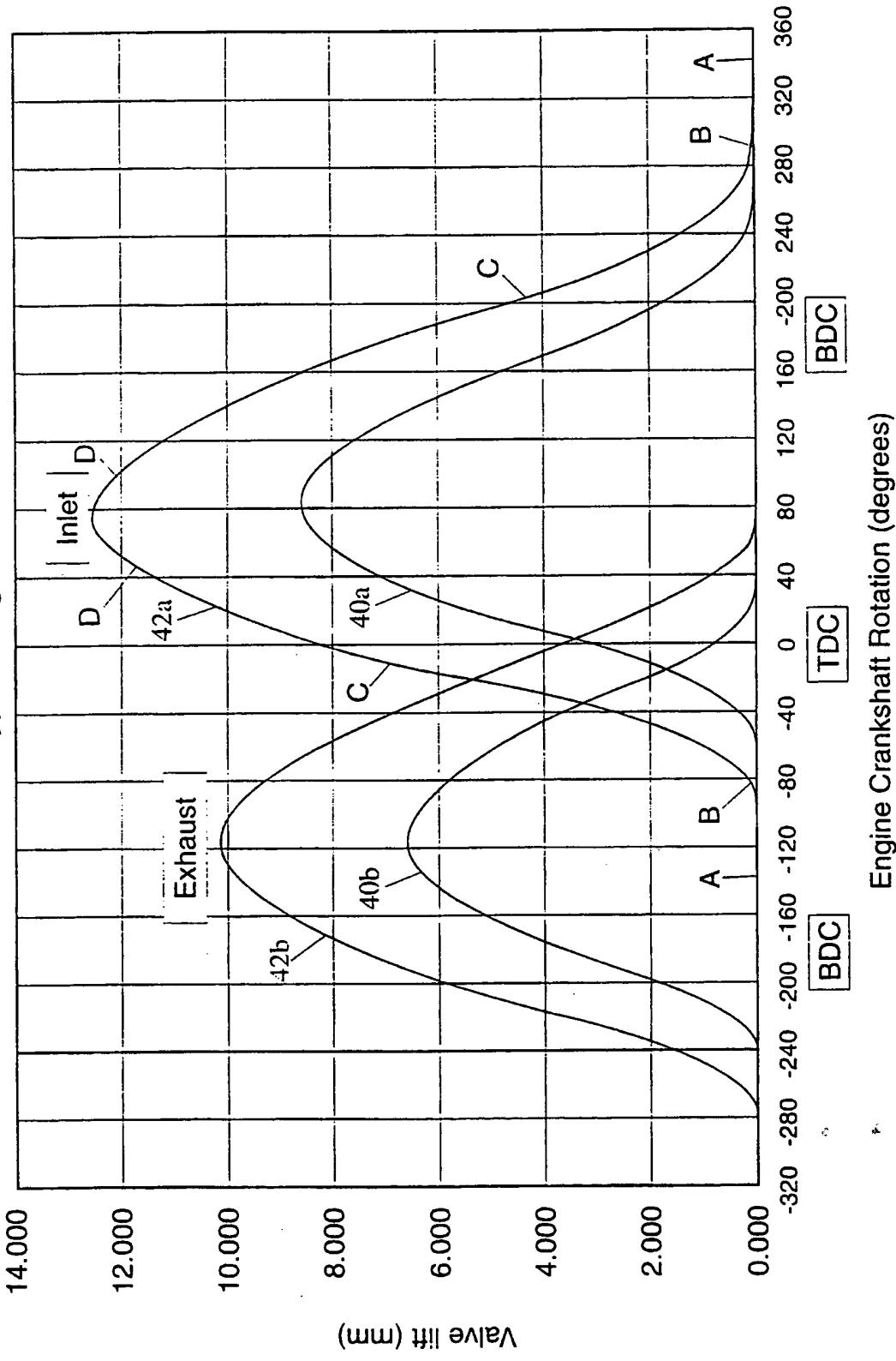


Fig6b.



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Fig 7. First Prototype, Range of Variation

**SUBSTITUTE SHEET (rule 26)**

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Fig 8.

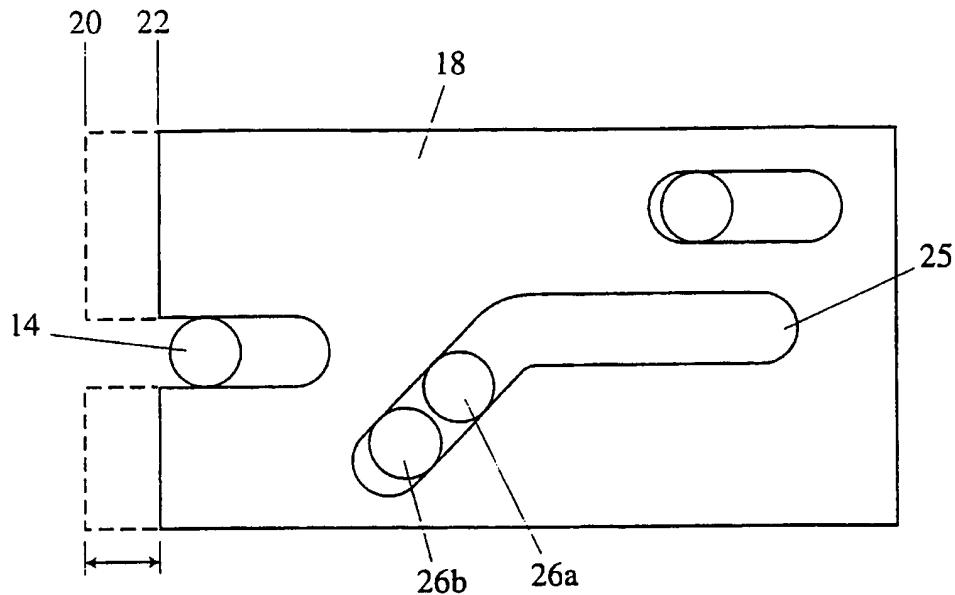
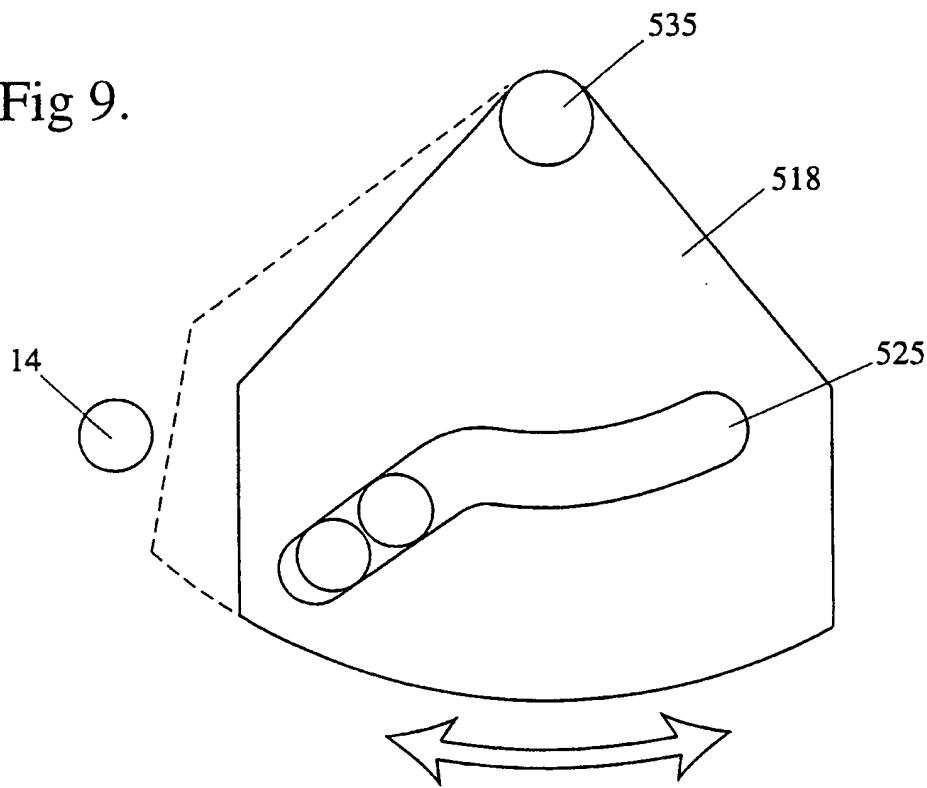


Fig 9.



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Fig 10a.

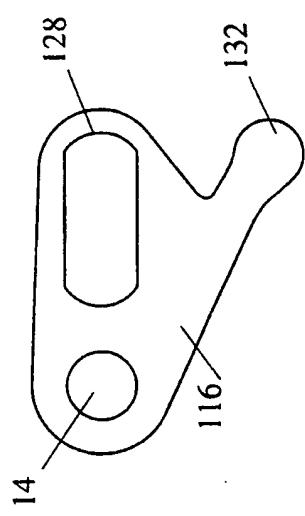


Fig 10c.

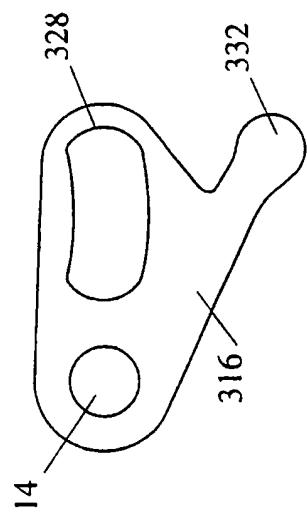


Fig 10b.

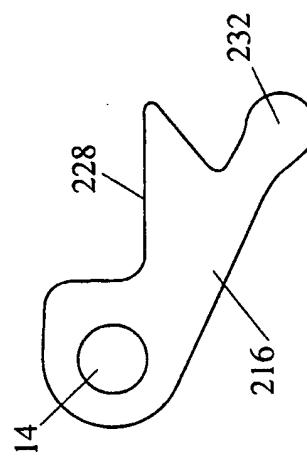
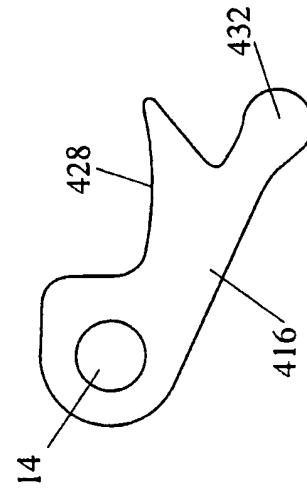


Fig 10d.



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Fig 11.

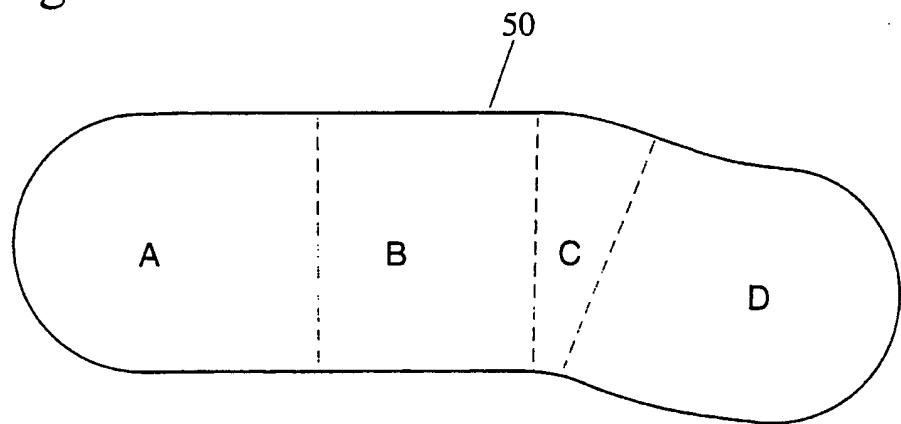
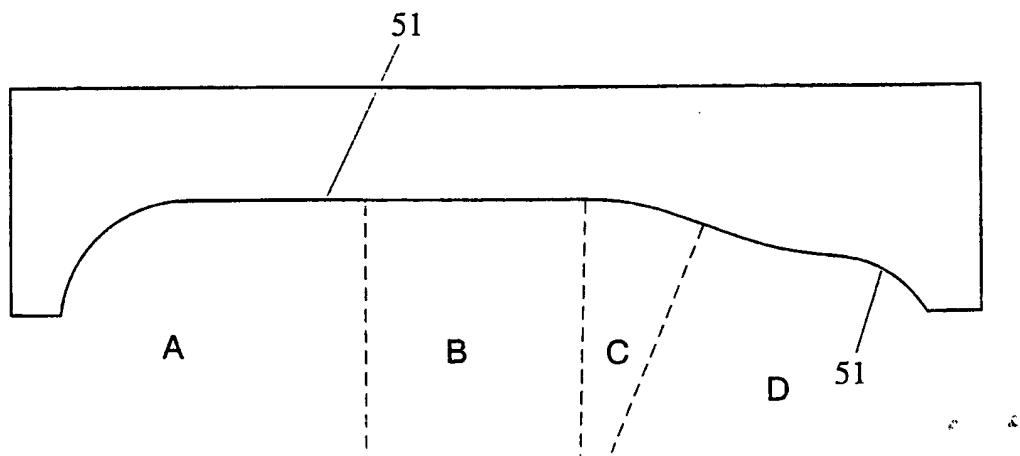


Fig 12.



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Fig 13.

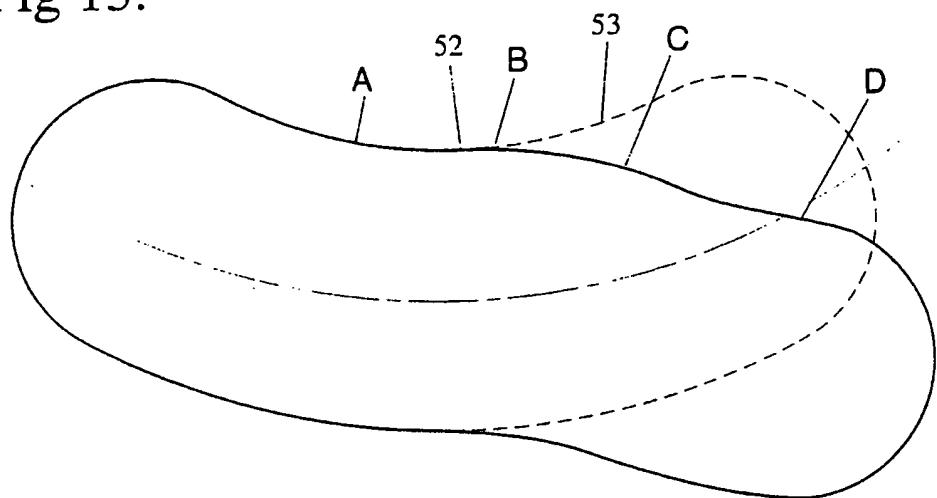
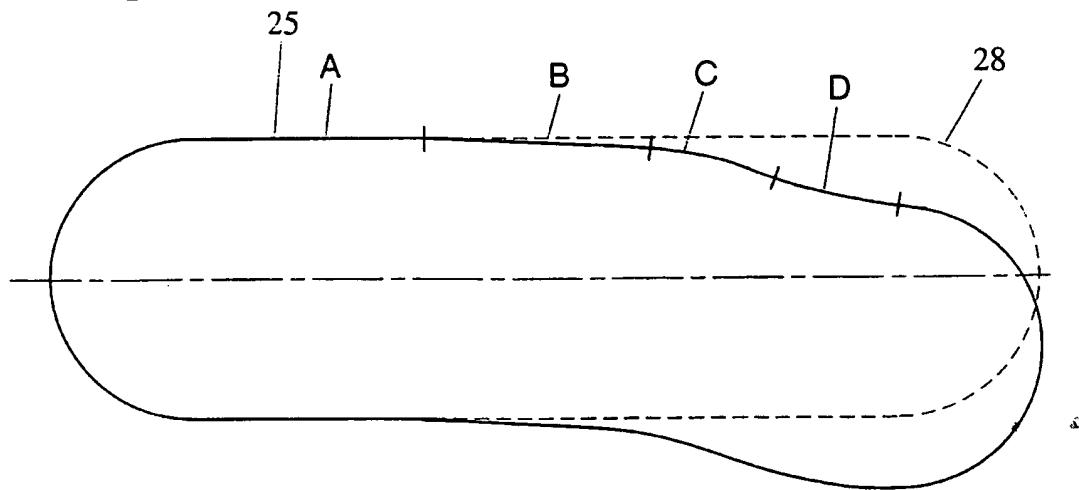


Fig 14.



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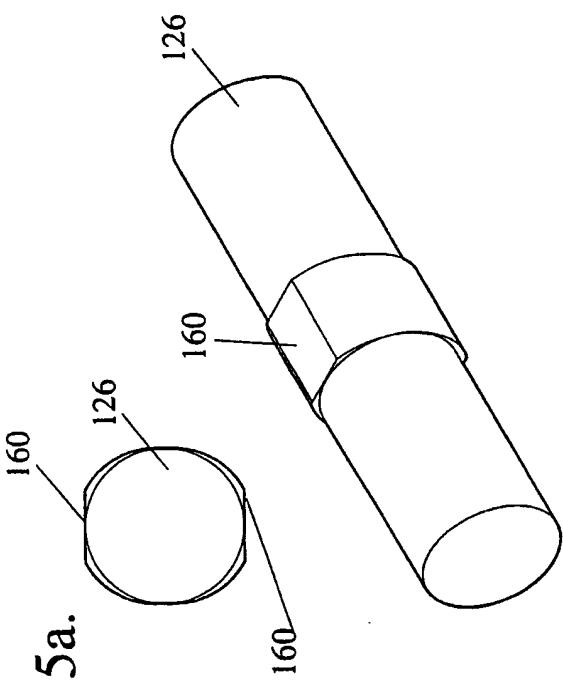


Fig 15a.

Fig 15c.

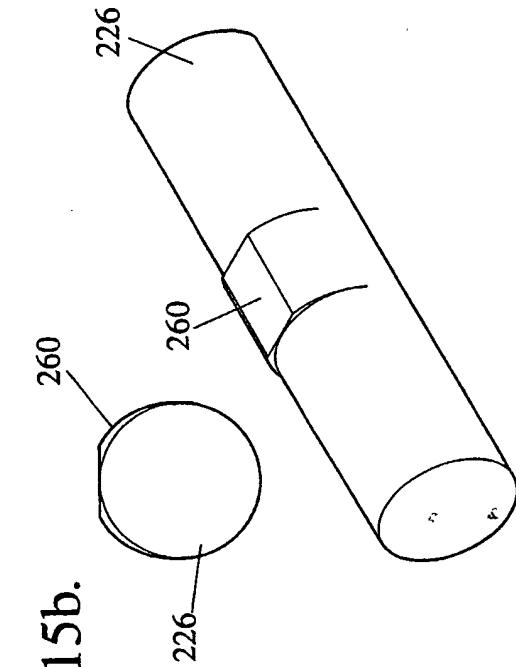
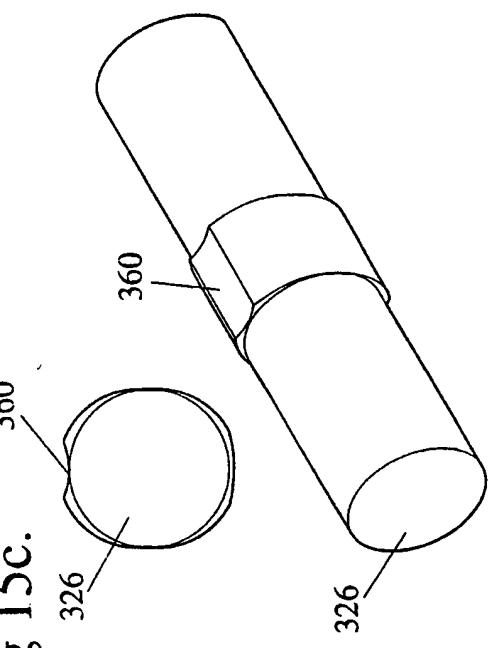
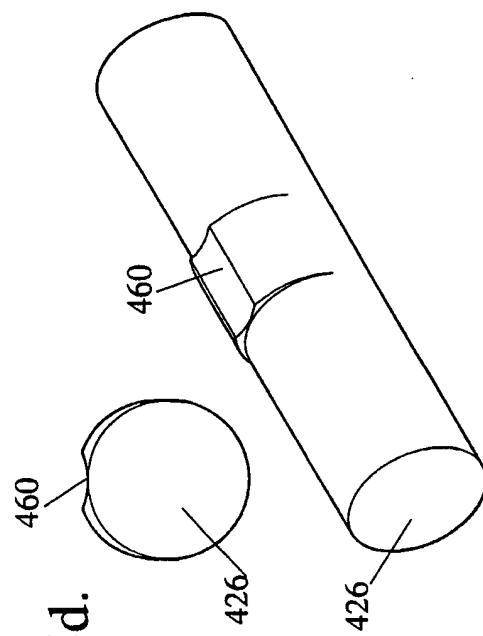


Fig 15b.

Fig 15d.



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Fig 16c.

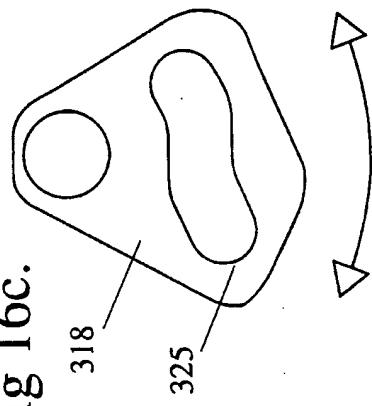


Fig 16d.

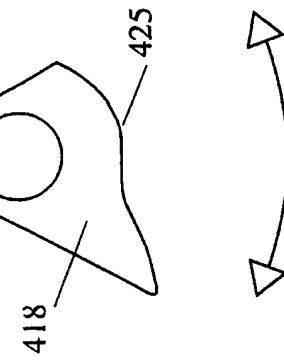


Fig 16a.

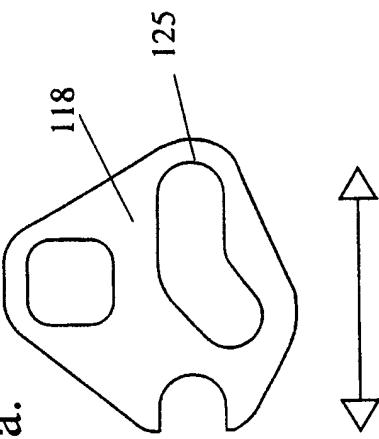
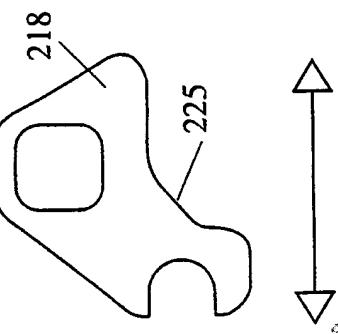
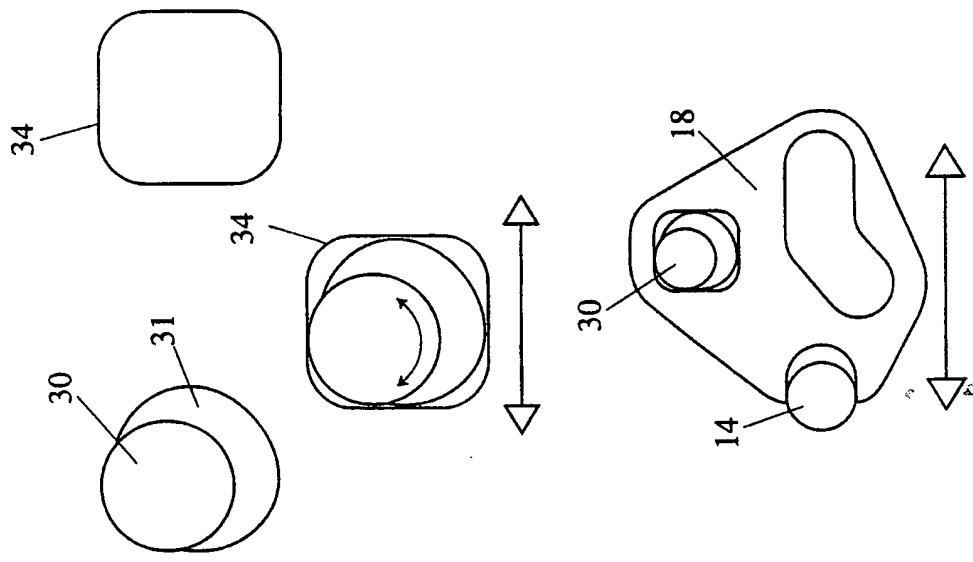
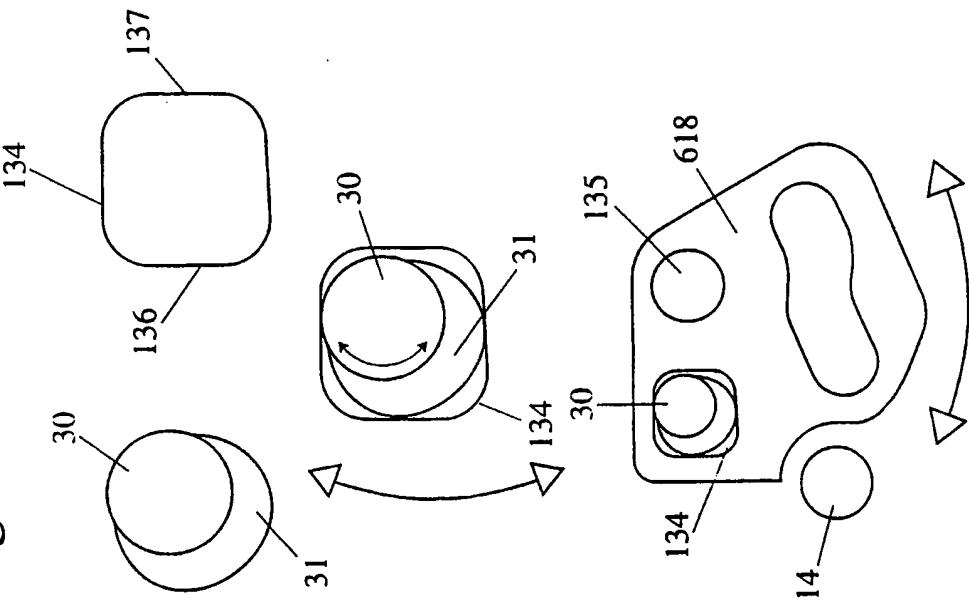


Fig 16b.



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Fig 17a.**Fig 17b.**

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Fig 18a.

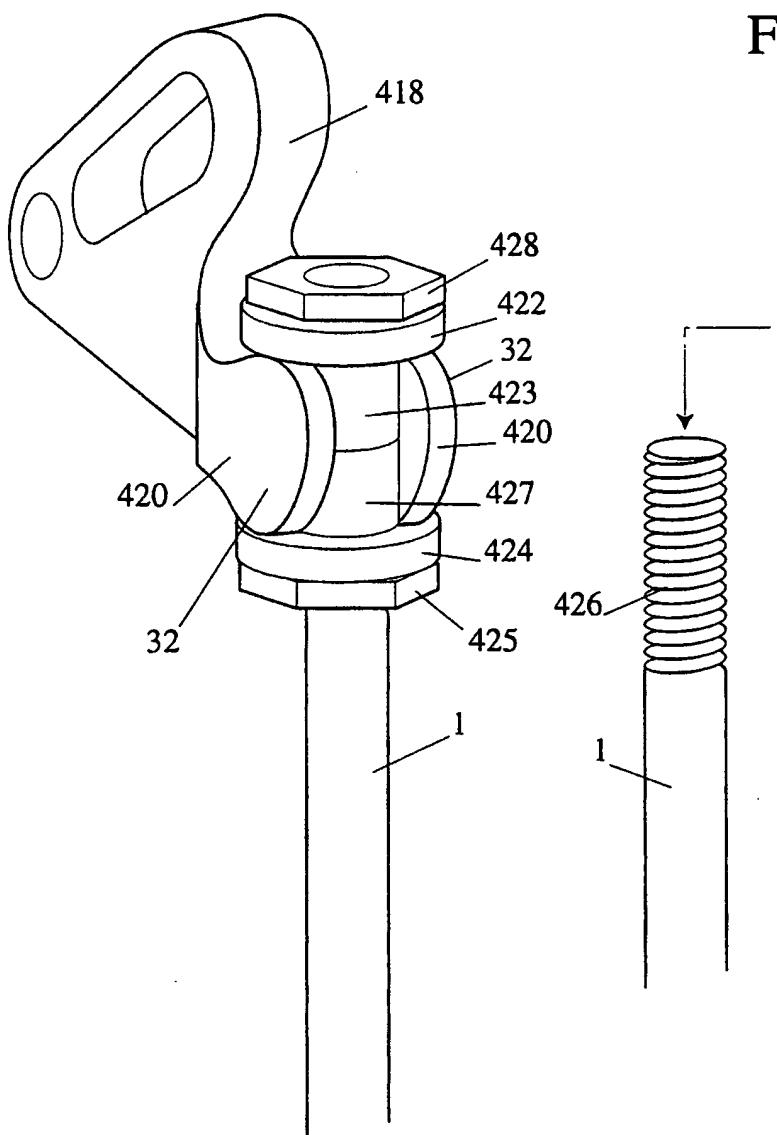
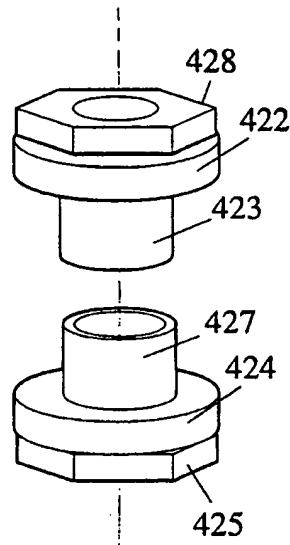


Fig 18b.



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